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TRANSIT TEMPERATURES AND ARRIVAL CONDITION OF CALIFORNIA LETTUCE AND TABLE GRAPES SHIPPED TO THE FAR EAST

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Washington, D.C.

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Transit Temperatures and Arrival Condition of California Lettuce and Table Grapes Shipped to the Far East

By C. Max Harris and John M. Harvey[1]

SUMMARY

Transit temperatures in three van containers of lettuce, loaded in an air-stack pattern, averaged about 36° F (2.0° C) during 15 days in transit from Oakland, Calif., to Hong Kong. Temperatures throughout the loads varied by only 2° to 3° F (1.0° to 1.5° C) from the average.

Atmospheres in two of the van containers loaded with lettuce were modified at shipping point. The third van container was a normal air control.

Market quality differences were slight between lettuce shipped in air and lettuce shipped in an atmosphere averaging 10 percent oxygen.

Carbon dioxide buildup in all lettuce loads was 1.5 percent or less during transit.

Each of the two modified atmosphere (MA) vans contained lettuce from a different field (called lots A and B) and the control van (normal air) had samples of both lots of lettuce. Lot B lettuce had about three times more decay and significantly fewer salable heads on arrival than lot A lettuce, regardless of type of van used in shipment.

Transit temperatures in two precooled, palletized loads of grapes, packed in polystyrene foam boxes, stabilized near the 36° F (2.0° C) thermostat setting by the third day in transit. Temperature variation in these grapes did not exceed 2° F (1.0° C) during most of the trip.

Arrival condition of the grapes was excellent in both loads. Less decay occurred in 'Ribier' than in 'Exotic' or 'Thompson Seedless' grapes, but shattering was greatest in 'Thompson Seedless.'

INTRODUCTION

Export of lettuce and table grapes from California to Far Eastern markets has increased steadily over the last 10 years. In 1975, about 14.5 million pounds of lettuce and 13.5 million pounds of grapes were exported to Hong Kong. The combined value of these exports was over $6.5 million. As the volume of exported commodities increases, the need to reduce losses and maintain quality during ocean transport becomes increasingly important.

Lettuce

Although many researchers have reported the effects of controlled atmospheres (CA) on the quality of head lettuce, most experiments lasted only about 1 week and showed no beneficial effects from low oxygen (O_2) atmospheres, other than a reduced incidence of russet spotting (*3*, *5*, *7*, *8*).[2] Elevated carbon dioxide (CO_2) levels cause the brown stain disorder (*7*). Studies on the effect of CA on lettuce dur-

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[2] Italic numbers in parentheses refer to Literature Cited, p. 8.

ing actual (*6*) or simulated (*4*) overseas shipments that took 4 weeks or longer showed significantly less loss of edible lettuce during storage in 3 to 5 percent O_2 than they did in air (21 percent O_2). Lipton (*4*) found that 2 percent CO_2 combined with 3 percent O_2 resulted in higher quality lettuce after storage than when a low O_2 level alone was used.

The specific objectives of our shipping test with lettuce were as follows: (1) to determine transit temperatures in van container loads of lettuce; (2) to measure O_2 and CO_2 levels in lettuce loads, with and without initial atmosphere modification; (3) to determine the effects of these variables on the arrival condition of the product; and (4) to observe general handling techniques used in transit and in foreign distribution systems.

Grapes

A considerable portion of the California table grape crop is now being shipped in polystyrene foam boxes (*2*) palletized at shipping point. Most grapes are precooled to at least 40° F (4.5° C) prior to long term storage at 31° to 32° F (0° C) or loading in a transport vehicle. No data are available on the effects of the new grape boxes and palletization on temperatures of the fruit during long ocean voyages. The objectives of the grape test were as follows: (1) to measure transit temperatures in palletized loads of grapes packed in the polystyrene foam boxes, (2) to determine O_2 and CO_2 levels in palletized loads of grapes, (3) to determine the amount of berry shatter and decay on arrival, and (4) to observe general handling techniques and distribution methods at destination.

METHODS

Lettuce

The three van containers of lettuce were loaded in Salinas, Calif., on September 4, 1975, and transported over the road to Oakland, Calif., where they were loaded onto the container ship the following day. Two of the vans were designed to hold a modified atmosphere (MA) during transit, and the other was not modified (normal air van). The MA vans were made airtight after loading and were purged with nitrogen gas to reduce the O_2 level in the van. Bags of lime were placed on top of the MA loads to absorb excess CO_2 produced by the respiring lettuce.

All three vans were equipped with the carrier's newest refrigeration units (Thermoking Model M-6) with continuously operating fans. Each MA van had six test cartons of film-wrapped lettuce placed in the top, middle, and bottom layers of the load at the ¼-length and ¾-length locations. Each of the two vans contained lettuce from a different field, designated as lots A and B, respectively. The control (normal air) van had six cartons of each of the two lots of test lettuce (total of 12 cartons) placed at comparable positions in the load. Lettuce in all vans was stowed in an air-stack loading pattern to provide longitudinal air channels through the middle layers of the loads (fig. 1).

Lettuce temperatures were monitored by thermocouples inserted about 1 inch (2.5 cm) into individual heads in boxes at the 12 locations indicated in figure 2. Additional thermocouples were used to monitor temperatures at the air discharge and return and under the floor at the ½-length location. The O_2 and CO_2 levels in the vans were determined daily by withdrawing samples of the atmosphere through tubes installed in special ports in the vans and measuring gas concentrations with portable, volumetric-type gas analyzers.

Grapes

Two refrigerated van containers were loaded with 1,104 palletized, polystyrene foam boxes, each packed with about 24.5 pounds (11.1 kilograms) of grapes (fig. 3). The vans were loaded near Delano, Calif., on September 4 and trucked to Oakland on the same day. One van contained four test boxes of 'Ribier' and four boxes of 'Thompson Seedless' grapes. The other van contained four test boxes of 'Exotic' grapes. Grape temperatures were measured at 12 locations with thermocouples inserted into individual berries in boxes placed in the top, center, bot-

tom, and side of pallets located in the front, ½ length, and rear of each van. Additional thermocouples were used to measure temperatures at the air discharge, air return, and under the floor at the ½-length location.

Temperatures of all test loads were measured twice daily, except at ocean carrier terminals where the vans were sometimes inaccessible.

The general condition of the loads was observed during unloading at Hong Kong, and the sample cartons of produce were recovered for quality evaluation.

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FIGURE 1.—Lettuce after loading in Salinas, Calif. showing air-stack loading pattern for air circulation.

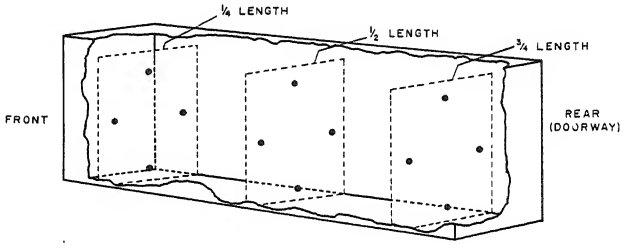
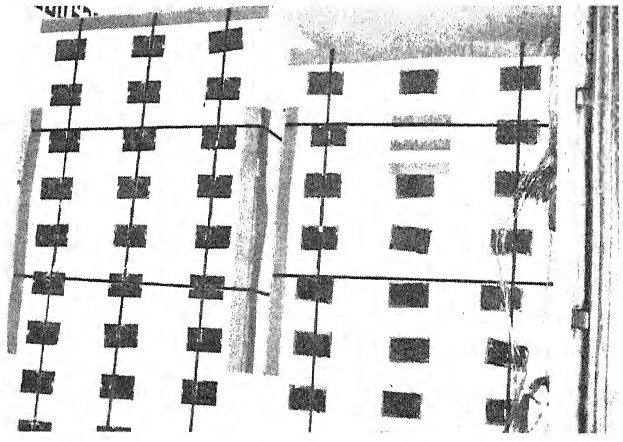


FIGURE 2.—Position of thermocouple sensing points in the lettuce loads.



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Temperatures in Transit

Lettuce temperatures were higher than opti mum (34° F, 1.0° C) in all test vans immedi ately after they were loaded (figs. 4, 5, 6). Lo A lettuce averaged 47° F (8.0° C), lot B lettuc averaged 41° F (5.0° C), and lettuce in th

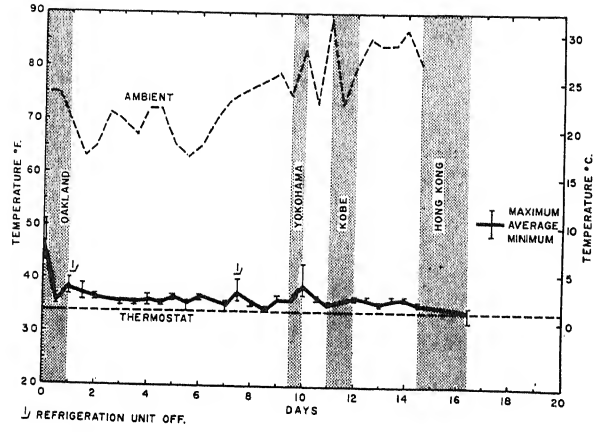

FIGURE 4.—Lettuce (lot A) temperatures during transit in modified atmosphere van container.

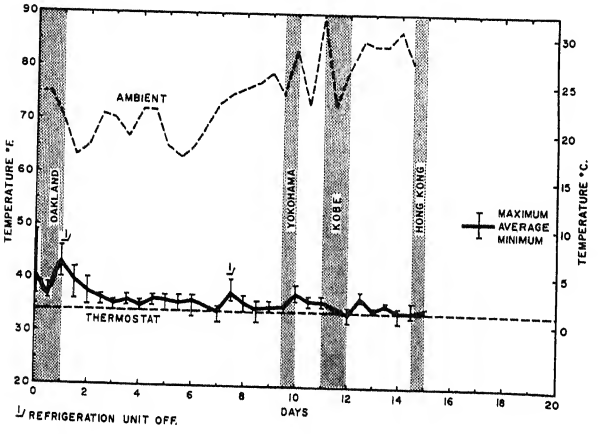

FIGURE 5.—Lettuce (lot B) temperatures during transit in modified atmosphere van container.

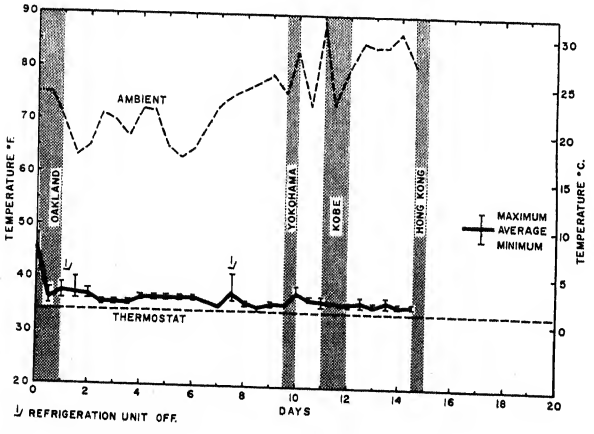

FIGURE 6.—Lettuce (lots A and B) temperatures during transit in normal air van container.

in the load averaged about 3° F (1.5° C) in the MA van with lot B lettuce, whereas the variation in the other two loads averaged about 2° F (1.0° C).

Grapes

The 'Ribier' and 'Thompson Seedless' grapes averaged 46° F (8.0° C) at loading (fig. 7), which is about 10° F (5.5° C) higher than the thermostat setpoint (36° F, 2.0° C) used on the vans. The 'Exotic' grapes averaged 39° F (4.0° C) after loading (fig. 8). The average temperature of both loads was near the 36° F (2.0° C) thermostat setpoint on the third day after loading and remained near that temperature, while the refrigeration units were operating normally. Temperature variation in the

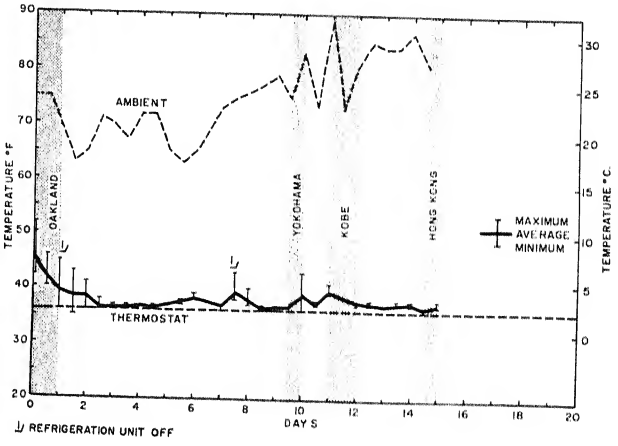

FIGURE 7.—'Ribier' and 'Thompson Seedless' varieties grape temperatures during transit in van container.

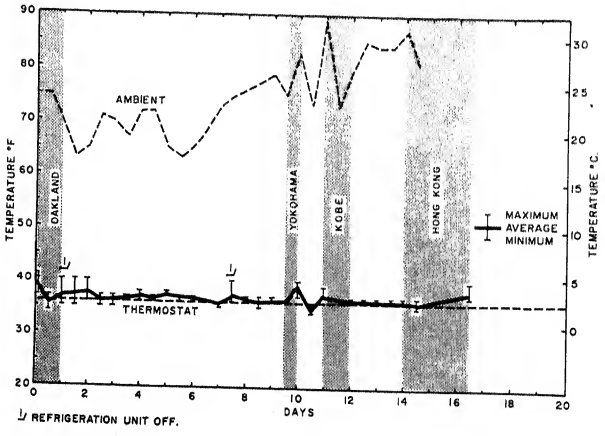

FIGURE 8.—'Exotic' variety grape temperatures during transit in van container.

loads was 2° F (1.0° C) or less after initial cool down during normal operation.

After being loaded aboard the ship, all test vans were operated by electric power that originated from a portable diesel generator. This generator malfunctioned on the first and seventh nights, which caused a loss of power to the refrigeration systems and a temporary increase in temperature. All units operated normally except for these two periods and during a stopover at Yokohama, where the vans were disconnected during unloading and reloading of other cargo.

Atmospheres in Transit

The MA van loaded with lot A lettuce had 14 percent O_2 and a negligible amount of CO_2 on arrival in Oakland and averaged about 10.5 percent O_2 for the remainder of the voyage (table 1). The MA van loaded with lot B lettuce had 17 percent O_2 and 1 percent CO_2 on arrival in Oakland (table 1), but 2 days later, the concentrations of O_2 and CO_2 had returned to those of normal air. Inspection of the van showed that an air vent, normally closed on MA vans, was slightly open, allowing gas exchange between the van interior and outside air. The vent was resealed, but the van could not be purged with nitrogen at that time. Consequently, the O_2 level averaged about 18 percent for the remainder of the voyage, which cannot be considered a true MA condition. The CO_2 level in both MA vans did not exceed 1.5 percent during transit.

The control lettuce van and the two vans loaded with grapes averaged about 20.5 percent O_2 and 1.5 percent CO_2 during transit.

Arrival Condition of Produce

Lettuce

Lot A lettuce arrived with significantly less decay and more salable heads than lot B lettuce whether shipped in the MA or control van. Decay of lot A lettuce averaged 13 percent in the MA van and 10 percent in the regular air van, whereas decay of Lot B lettuce averaged 35 percent in the MA van and 30.5 percent in the regular air van. The percentage of salable heads in lot A lettuce averaged 90 percent in the MA van and 94 percent in the regular air van, whereas percent salable heads in lot B averaged 79 percent in the MA van and 72 percent in the regular air van.

There were no significant differences between lot B lettuce shipped in the regular air van or in the MA van, which had not been properly sealed.

Lot A lettuce, shipped in the MA van that averaged 10.5 percent O_2 during transit, showed

TABLE 1.—*Concentrations (percent) of oxygen and carbon dioxide in modified atmosphere vans during transit*

Date Sept. 1975	Van containing lot A		Van containing lot B	
	CO_2	O_2	CO_2	O_2
	Percent			
5 (Leave Oakland)	——	14.0	1.0	17.0
6	0.5	10.5	1.0	16.0
7	.5	10.0	[1]0	[1]20.5
8	.5	10.0	.5	19.5
[2]9	.5	[illegible]	.5	19.0
11	[illegible]			
12				
13				
14 (Arrive Yokohama)				
15 (Leave Yokohama)				
16 (Arrive Kobe)				
17 (Leave Kobe)				
18				
19				
20 (Arrive Hong Kong)				
24 (Unloaded)				

[1] Exhaust vent in van foun

[2] Crossed international dat

less butt discoloration and had less trim waste on arrival than the same lot of lettuce shipped in the regular air van (table 2); the incidence of decay and the quality ratings were not influenced by transit atmospheres. Other lettuce defects, such as russet spotting, pink rib, and rib discoloration, were rare in all loads. The significant difference in head weight found in lot A lettuce (table 2) is unexplained and unrelated to any treatment, and its effect on trim loss is unknown.

Crushing and bruising damage was common in both lots of lettuce and averaged about 92 percent in lot A lettuce and 88 percent in lot B lettuce. Heads rated with slight, moderate, or severe crushing and bruising constituted 43, 44, and 13 percent, respectively, of the damaged heads from all loads.

Grapes

Both grape loads arrived in excellent condition. The amount of decay and berry shatter found in the various cultivars of grapes on arrival in Hong Kong is summarized in table 3. 'Exotic' grapes had slightly more decayed berries (2.2 percent), and the 'Thompson Seedless' had slightly more shattered berries (1.8 percent) than the other two cultivars; however, the total amounts of the defects were minor in all varieties. Weight loss was not measurable in any variety during transit.

Load Condition on Arrival

Lettuce cartons in the bottom layers of all loads showed crushing damage, which caused

TABLE 2.—*Quality and condition of lot A lettuce shipped in a modified atmosphere and a normal air van* [1]

Type of van	Quality criteria		Condition criteria[4]					
			Decay					
	Salable heads[2]	Appearance[3]	Affected heads	Severity of affected heads	Butt discoloration	Average head weight (grams)	Retail trim[5]	Consumer trim[6]
	Percent[1]	*Rating*	*Percent*	*Rating*	*Rating*	*Number*	*Percent*	*Percent*
Modified atmosphere	90a	6.0a	13a	4.0a	3.2a	734a	1.5a	6.1a
Normal air	94a	5.7a	10a	3.9a	4.6b	666b	1.2a	10.0b

[1] Means in a given column without a letter in common differ at P 95 percent.
[2] Salability evaluated before film removal.
[3] Appearance rating made after film removal: 1, extremely poor; 3, poor; 5, fair; 7, good; 9, excellent.
[4] Condition ratings: 1, none; 3, slight; 5, moderate; 7, severe; 9, extreme.
[5] Weight of lettuce removed to make head salable.
[6] Includes all defective tissue in head not removed by retail trim.

TABLE 3.—*Market losses in table grapes on arrival in Hong Kong*

Variety	Decayed berries		Shattered berries		Weight loss in transit
	No./box[1]	*Percent by weight*	*No./box*[1]	*Percent by weight*	*Percent*
'Thompson Seedless'	31	0.9	64	1.8	Nil
'Ribier'	4	.3	16	1.2	Nil
'Exotic'	26	2.2	11	.9	Nil

[1] Average of 4 test boxes.

some damage to the lettuce itself (fig. 9). However, the high incidence of crushing and bruising of lettuce in the test cartons was largely due to the wide variation in the maturity of heads in the same carton, which resulted in hard, overmature heads being pushed into softer, immature heads.

No damage to polystyrene boxes was found in the grape loads, and the boxes retained good alinement on the pallets. Palletization of grapes is advantageous during shipping point handling, but has little advantage at destination in Hong Kong, which has no facilities for unloading unitized loads of produce. Consequently, the individual boxes were unloaded by hand (fig. 10).

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FIGURE 9.—Package damage in bottom layer of lettuce load on arrival in Hong Kong.

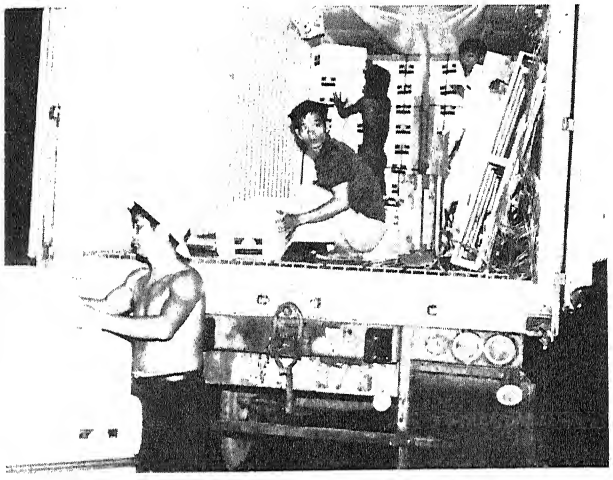

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FIGURE 10.—Palletized grapes being unloaded by hand in Hong Kong.

DISCUSSION

The van's refrigeration system and the air-stack loading pattern were effective in maintaining uniform lettuce temperatures in the three test loads.

Quality differences at destination were small between lettuce shipped in a normal air atmosphere and lettuce shipped in an atmosphere containing 10 to 11 percent O_2 (lot A). The slightly higher trim waste found in lettuce shipped in normal air resulted in part from slightly more severe crushing damage in that van than in the MA van. Butt discoloration, which was less severe in lettuce from the MA than in lettuce from the regular air van (table 2), is a minor defect caused by the oxidation of cut stem tissue after harvesting. Browning of the cut stem is a normal consequence of harvesting and usually varies widely among heads from the same lot (*3*). Butt discoloration is not scored as a defect in official USDA market inspections for lettuce (*1*) and is not a good indication of lettuce quality.

Results of previous studies with lettuce (*4*, *6*) indicate that the optimum O_2 level for extended intransit storage is about 3 to 5 percent. In the present test, only slight differences in quality were observed between lettuce shipped in 10 percent O_2 and that shipped in normal air. However, the combination of 2 percent CO_2 and low O_2 may be preferable to low O_2 alone (*4*), but this combination cannot be recommended for extended overseas shipments until further tests are made.

Precooled grapes, packed in polystyrene boxes and unitized on pallets, remained at desirable temperatures during the 15-day transit period. The importance of thorough precooling must be stressed because this type of load

would cool very slowly in the van (see fig. 7). Although shipment on pallets is satisfactory for grapes, this technique may not be desirable for other commodities because the heat of respiration in some commodities is two to three times as great as that of grapes at the same temperature. When palletized, such produce could suffer from excessively high temperatures in the centers of pallets.

Cooling and warming rates are slower for grapes packed in polystyrene boxes than for those packed in wood boxes (*2*). Although the slower response to temperature change is a disadvantage during cooling at shipping point and after loading in the van, it may be an advantage when grapes are removed from the van container in Hong Kong, where they are not refrigerated during distribution and marketing.

Delays of 1 to 6 days are common in unloading produce after the van containers are removed from the ship in Hong Kong. Such delays are usually at the request of the receiver who uses the van container for refrigerated storage while awaiting better marketing conditions for the produce. This delay adds to the already long transit period for commodities shipped to this destination and should be considered when selecting particular lots of produce for export.

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